

Electricity and Magnetism, Italy, IEN (Istituto Elettrotecnico Nazionale Galileo Ferraris)



Calibration or Measurement Services			Measurand Level or Range			Measurement Conditions/Independent variables		Expanded Uncertainty							
Quantity	Instrument or artifact	Instrument Type or Method	Minimum value	Maximum value	units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Is the expanded uncertainty a relative one?	Uncertainty matrix	Comments	NMI Service Identifier
DC voltage sources: single values	Voltage standard	Comparison with standard cells	1.018	1.018	V			1	µV/V	2	95%	Yes		Higher uncertainty for humidity sensitive Zeners	1
DC voltage sources: single values	Voltage standard	Comparison with 10 V reference standard	10	10	V			0.5	µV/V	2	95%	Yes			2
DC voltage sources: single values	Voltage standard	Comparison with standard cells	1	1	V			1	µV/V	2	95%	Yes			3
DC voltage sources: low values	Multifunction calibrator	Voltage standard, resistive divider	0.001	10	V			200 to 1.5	µV/V	2	95%	Yes			4
DC voltage sources: intermediate values	Multifunction calibrator	Voltage standard, resistive divider	10	200	V			1.5	µV/V	2	95%	Yes			5
DC voltage sources: intermediate values	Multifunction calibrator	Voltage standard, resistive divider	200	1000	V			3	µV/V	2	95%	Yes			6
DC voltage meters: intermediate values	Digital multimeter	Direct with calibrator	0.001	200	V			250 to 2.5	µV/V	2	95%	Yes			7
DC voltage meters: intermediate values	Digital multimeter	Direct with calibrator	200	1000	V			4	µV/V	2	95%	Yes			8
DC voltage ratios: up to 1100 V	Kelvin-Varley divider	Self-calibration	1.00E-06	1				2.0E-07		2	95%	No			9
DC voltage ratios: up to 1100 V	Resistive divider	Comparison with reference divider	0.1	1		Input voltage	100 V	2.5E-07		2	95%	Yes			10
						Ratio	0.1 to 1, by step of 0.1								
DC voltage ratios: up to 1100 V	Resistive divider	Comparison with reference divider	0.01	1		Input voltage	1000 V	5.0E-07		2	95%	Yes			11
						Ratio	from 0.01 to 0.1 by step of 0.01 and from 0.1 to 1 by step of 0.1								
DC resistance standards and sources: low values	Fixed resistor	Comparison by means of high current DCC bridge	0.1	0.1	mΩ	Power	10 mW	15	µΩ/Ω	2	95%	Yes			12

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DC resistance standards and sources: low values	Fixed resistor	Comparison by means of high current DCC bridge	1	1	mΩ	Power	10 mW	5	μΩ/Ω	2	95%	Yes			13
DC resistance standards and sources: low values	Fixed resistor	Comparison by means of high current DCC bridge	10	10	mΩ	Power	10 mW	3	μΩ/Ω	2	95%	Yes			14
DC resistance standards and sources: low values	Fixed resistor	Comparison by means of high current DCC bridge	100	100	mΩ	Power	10 mW	2	μΩ/Ω	2	95%	Yes			15
DC resistance standards and sources: intermediate values	Fixed resistor	Comparison by means of automatic DCC bridge	1	10000	Ω	Power	10 mW	0.5	μΩ/Ω	2	95%	Yes			17
DC resistance standards and sources: intermediate values	Fixed resistor	Substitution using a multimeter	100	100	kΩ	Voltage	10 V	2	μΩ/Ω	2	95%	Yes			19
DC resistance standards and sources: intermediate values	Fixed resistor	Substitution using a multimeter	1	1	MΩ	Voltage	10 V	3	μΩ/Ω	2	95%	Yes			20
DC resistance standards and sources: high values	Fixed resistor	Substitution using a multimeter	10	10	MΩ	Voltage	10 V	6	μΩ/Ω	2	95%	Yes			21
DC resistance standards and sources: high values	Fixed resistor	Calibrator and multimeter	100	100	MΩ	Voltage	100 V	15	μΩ/Ω	2	95%	Yes			23
DC resistance standards and sources: high values	Fixed resistor	Calibrator and multimeter	1	1	GΩ	Voltage	100 V	20	μΩ/Ω	2	95%	Yes			24
DC resistance standards and sources: high values	Fixed resistor	Calibrator and multimeter	10	10	GΩ	Voltage	500 V	40	μΩ/Ω	2	95%	Yes			25
DC resistance standards and sources: high values	Fixed resistor	Calibrator and multimeter	100	100	GΩ	Voltage	500 V	200	μΩ/Ω	2	95%	Yes			26

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DC resistance standards and sources: high values	Fixed resistor	Calibrator and multimeter	1	1	TΩ	Voltage	1000 V	1000	μΩ/Ω	2	95%	Yes			27
DC resistance standards and sources: standards for high current	DC shunt	Volt-amperometric	10	10000	μΩ	Current	<= 800 A	0.5	mΩ/Ω	2	95%	Yes			29
DC resistance sources: multiple ranges	Multifunction calibrator	Standard resistor and multimeter	1	1	Ω			10	μΩ/Ω	2	95%	Yes			30
DC resistance sources: multiple ranges	Multifunction calibrator	Standard resistor and multimeter	10	10	Ω			5	μΩ/Ω	2	95%	Yes			31
DC resistance sources: multiple ranges	Multifunction calibrator	Standard resistor and multimeter	0.1	10	kΩ			3	μΩ/Ω	2	95%	Yes			32
DC resistance sources: multiple ranges	Multifunction calibrator	Standard resistor and multimeter	100	1000	kΩ			5	μΩ/Ω	2	95%	Yes			33
DC resistance sources: multiple ranges	Multifunction calibrator	Standard resistor and multimeter	10	10	MΩ			20	μΩ/Ω	2	95%	Yes			34
DC resistance sources: multiple ranges	Multifunction calibrator	Standard resistor and multimeter	100	100	MΩ			60	μΩ/Ω	2	95%	Yes			35
DC resistance meters: low values	Digital multimeter	Direct with calibrator	1	1	Ω			20	μΩ/Ω	2	95%	Yes		Measurement on the 10 Ω range	36
DC resistance meters: intermediate values	Digital multimeter	Direct with calibrator	10	10	Ω			10	μΩ/Ω	2	95%	Yes			37
DC resistance meters: intermediate values	Digital multimeter	Direct with calibrator	0.1	1000	kΩ			5	μΩ/Ω	2	95%	Yes			38
DC resistance meters: intermediate values	Digital multimeter	Direct with calibrator	10	10	MΩ			30	μΩ/Ω	2	95%	Yes			39
DC resistance meters: intermediate values	Digital multimeter	Direct with calibrator	100	100	MΩ			80	μΩ/Ω	2	95%	Yes			40
DC current sources: low values	Multifunction calibrator	Standard resistor and multimeter	10	100	μA			20 to 50	μA/A	2	95%	Yes			41

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DC current sources: intermediate values	Multifunction calibrator	Standard resistor and multimeter	0.1	200	mA			10	µA/A	2	95%	Yes			42
DC current sources: intermediate values	Multifunction calibrator	Standard resistor and multimeter	0.2	2	A			20	µA/A	2	95%	Yes			43
DC current sources: intermediate values	Multifunction calibrator	Shunt and multimeter	2	10	A			30	µA/A	2	95%	Yes			44
DC current meters: low values	Digital multimeter	Direct with calibrator	10	100	µA			25 to 75	µA/A	2	95%	Yes			45
DC current meters: intermediate values	Digital multimeter	Direct with calibrator	0.1	200	mA			15	µA/A	2	95%	Yes			46
DC current meters: intermediate values	Digital multimeter	Direct with calibrator	0.2	2	A			30	µA/A	2	95%	Yes			47
Capacitance: low loss capacitors	2-port or 4-port standard capacitor	Transformer bridge with substitution	1	1000	pF	Frequency	1.592 kHz	2	µF/F	2	95%	Yes			51
						Capacitance	1 pF, 10 pF, 100 pF, 1000 pF								
Capacitance: dielectric capacitors	2-port capacitor	Automatic capacitance bridge	0.001	1	nF	Frequency	1 kHz	5	µF/F	2	95%	Yes			52
Capacitance: dielectric capacitors	2-port or 3-terminal capacitor	Automatic capacitance bridge	1	10	nF	Frequency	1 kHz	5 to 10	µF/F	2	95%	Yes			53
Capacitance: dielectric capacitors	2-port or 3-terminal capacitor	Automatic capacitance bridge	10	100	nF	Frequency	1 kHz	10 to 25	µF/F	2	95%	Yes			54
Capacitance: dielectric capacitors	2-port or 3-terminal capacitor	Automatic capacitance bridge	0.1	1	µF	Frequency	1 kHz	25 to 50	µF/F	2	95%	Yes			55
Inductance: self inductance, intermediate values	Fixed inductor	Three-voltage method	0.001	1	H	Frequency	1 kHz	30	µH/H	2	95%	Yes			56
Inductance: self inductance, low values	Fixed inductor	Substitution	0.0001	0.001	H	Frequency	1 kHz	100	µH/H	2	95%	Yes			57a

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Inductance: self inductance, intermediate values	Fixed inductor	Substitution	0.001	1	H	Frequency	1 kHz	100	µH/H	2	95%	Yes			57b
Inductance: self inductance, high values	Fixed inductor	Substitution	1	10	H	Frequency	100 Hz	100	µH/H	2	95%	Yes			58
AC voltage: AC/DC transfer difference at low voltages	AC/DC transfer standard	Transfer standards and resistive dividers	1	300	mV	Frequency	40 Hz to 1 MHz	25 to 1000	µV/V	2	95%	Yes	ACDC_MV		59.a
AC voltage: AC/DC transfer difference at medium voltages	AC/DC transfer standard	Comparison with reference standard	0.2	5	V	Frequency	40 Hz to 1 MHz	4 to 50	µV/V	2	95%	Yes	ACDC_M1		66.a
AC voltage: AC/DC transfer difference at high voltages	AC/DC transfer standard	Comparison with reference standard	5	1000	V	Frequency	40 Hz to 1 MHz	5 to 100	µV/V	2	95%	Yes	ACDC_M1		73.a
AC voltage up to 1000V: sources	Multifunction calibrator	AC/DC transfer standard	1	200	mV	Frequency	40 Hz to 20000 Hz	1000 to 40	µV/V	2	95%	Yes			85
AC voltage up to 1000V: sources	Multifunction calibrator	AC/DC transfer standard	0.2	20	V	Frequency	40 Hz to 20000 Hz	30	µV/V	2	95%	Yes			86
AC voltage up to 1000V: sources	Multifunction calibrator	AC/DC transfer standard	0.2	20	V	Frequency	20 kHz to 100 kHz	100	µV/V	2	95%	Yes			87
AC voltage up to 1000V: sources	Multifunction calibrator	AC/DC transfer standard	0.2	20	V	Frequency	100 kHz to 500 kHz	500	µV/V	2	95%	Yes			88
AC voltage up to 1000V: sources	Multifunction calibrator	AC/DC transfer standard	0.2	20	V	Frequency	0.5 MHz to 1 MHz	1000	µV/V	2	95%	Yes			89
AC voltage up to 1000V: sources	Multifunction calibrator	AC/DC transfer standard	20	100	V	Frequency	40 Hz to 20000 Hz	50	µV/V	2	95%	Yes			90
AC voltage up to 1000V: sources	Multifunction calibrator	AC/DC transfer standard	20	100	V	Frequency	20 kHz to 50 kHz	100	µV/V	2	95%	Yes			91
AC voltage up to 1000V: sources	Multifunction calibrator	AC/DC transfer standard	20	100	V	Frequency	50 kHz to 100 kHz	200	µV/V	2	95%	Yes			92
AC voltage up to 1000V: sources	Multifunction calibrator	AC/DC transfer standard	100	700	V	Frequency	40 Hz to 20000 Hz	50	µV/V	2	95%	Yes			93
AC voltage up to 1000V: sources	Multifunction calibrator	AC/DC transfer standard	100	700	V	Frequency	20 kHz to 50 kHz	200	µV/V	2	95%	Yes			94
AC voltage up to 1000V: sources	Multifunction calibrator	AC/DC transfer standard	100	700	V	Frequency	50 kHz to 100 kHz	400	µV/V	2	95%	Yes			95
AC voltage up to 1000V: sources	Multifunction calibrator	AC/DC transfer standard	700	1000	V	Frequency	40 Hz to 20000 Hz	50	µV/V	2	95%	Yes			96
AC voltage up to 1000V: sources	Multifunction calibrator	AC/DC transfer standard	700	1000	V	Frequency	30 kHz	70	µV/V	2	95%	Yes			97
AC voltage up to 1000V: meters	AC voltage meter	AC source, standard divider	1	1	mV	Frequency	40 Hz to 10 kHz	1000	µV/V	2	95%	Yes			98

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AC voltage up to 1000V: meters	AC voltage meter	AC source, standard divider	5	5	mV	Frequency	40 Hz to 10 kHz	400	µV/V	2	95%	Yes			99
AC voltage up to 1000V: meters	AC voltage meter	AC source, standard divider	10	10	mV	Frequency	40 Hz to 10 kHz	200	µV/V	2	95%	Yes			100
AC voltage up to 1000V: meters	AC voltage meter	AC source, standard divider	30	30	mV	Frequency	40 Hz to 10 kHz	100	µV/V	2	95%	Yes			101
AC voltage up to 1000V: meters	AC voltage meter	AC source, standard divider	50	50	mV	Frequency	40 Hz to 10 kHz	80	µV/V	2	95%	Yes			102
AC voltage up to 1000V: meters	AC voltage meter	AC source, standard divider	100	100	mV	Frequency	40 Hz to 10 kHz	60	µV/V	2	95%	Yes			103
AC voltage up to 1000V: meters	AC voltage meter	AC source, standard divider	300	300	mV	Frequency	40 Hz to 10 kHz	40	µV/V	2	95%	Yes			104
AC voltage up to 1000V: meters	AC voltage meter	AC/DC transfer standard, DC source	0.2	1000	V	Frequency	20 Hz to 1 MHz	15 to 500	µV/V	2	95%	Yes	ACV_M1		105a
AC voltage up to 1000V: meters	Digital multimeter	Direct with calibrator	1	200	mV	Frequency	40 Hz to 20000 Hz	1000 to 40	µV/V	2	95%	Yes			124
AC voltage up to 1000V: meters	Digital multimeter	Direct with calibrator	0.2	20	V	Frequency	40 Hz to 20000 Hz	30	µV/V	2	95%	Yes			125
AC voltage up to 1000V: meters	Digital multimeter	Direct with calibrator	0.2	20	V	Frequency	20 kHz to 100 kHz	100	µV/V	2	95%	Yes			126
AC voltage up to 1000V: meters	Digital multimeter	Direct with calibrator	0.2	20	V	Frequency	100 kHz to 500 kHz	500	µV/V	2	95%	Yes			127
AC voltage up to 1000V: meters	Digital multimeter	Direct with calibrator	0.2	20	V	Frequency	500 kHz to 1 MHz	1000	µV/V	2	95%	Yes			128
AC voltage up to 1000V: meters	Digital multimeter	Direct with calibrator	20	100	V	Frequency	40 Hz to 20000 Hz	50	µV/V	2	95%	Yes			129
AC voltage up to 1000V: meters	Digital multimeter	Direct with calibrator	20	100	V	Frequency	20 kHz to 50 kHz	100	µV/V	2	95%	Yes			130
AC voltage up to 1000V: meters	Digital multimeter	Direct with calibrator	20	100	V	Frequency	50 kHz to 100 kHz	200	µV/V	2	95%	Yes			131
AC voltage up to 1000V: meters	Digital multimeter	Direct with calibrator	100	700	V	Frequency	40 Hz to 20000 Hz	50	µV/V	2	95%	Yes			132
AC voltage up to 1000V: meters	Digital multimeter	Direct with calibrator	100	700	V	Frequency	20 kHz to 50 kHz	200	µV/V	2	95%	Yes			133
AC voltage up to 1000V: meters	Digital multimeter	Direct with calibrator	100	700	V	Frequency	50 kHz to 100 kHz	400	µV/V	2	95%	Yes			134
AC voltage up to 1000V: meters	Digital multimeter	Direct with calibrator	700	1000	V	Frequency	40 Hz to 20000 Hz	50	µV/V	2	95%	Yes			135
AC voltage up to 1000V: meters	Digital multimeter	Direct with calibrator	700	1000	V	Frequency	20 kHz to 30 kHz	70	µV/V	2	95%	Yes			136
AC voltage ratio: real component	Inductive voltage divider	Comparison with reference divider	0.001	0.09		Voltage	<= 100 V	1.00E-07		2	95%	No	<i>This CMC is related to the next one</i>		137
						Frequency	400 Hz, 1000 Hz								
AC voltage ratio: imaginary component	Inductive divider	Comparison with reference divider	0.001	0.09		Voltage	<= 100 V	1.00E-06		2	95%	No	<i>This CMC is related to the previous one</i>		139

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						Frequency	400 Hz, 1000 Hz								
AC voltage ratio: real component	Inductive voltage divider	Comparison with reference divider	0.1	1		Voltage	<= 100 V	2.00E-07		2	95%	No		This CMC is related to the next one	138
						Frequency	400 Hz, 1000 Hz								
AC voltage ratio: imaginary component	Inductive voltage divider	Comparison with reference divider	0.1	1		Voltage	<= 100 V	2.00E-06		2	95%	No		This CMC is related to the previous one	140
						Frequency	400 Hz, 1000 Hz								
AC current: AC/DC transfer difference	AC/DC transfer standard	Comparison with reference standard	2.5	10	mA	Frequency	40 Hz to 20000 Hz	20	µA/A	2	95%	Yes			141
AC current: AC/DC transfer difference	AC/DC transfer standard	Comparison with reference standard	2.5	10	mA	Frequency	50 kHz to 100 kHz	50	µA/A	2	95%	Yes			142
AC current: AC/DC transfer difference	AC/DC transfer standard	Comparison with reference standard	10	100	mA	Frequency	40 Hz to 20000 Hz	50	µA/A	2	95%	Yes			143
AC current: AC/DC transfer difference	AC/DC transfer standard	Comparison with reference standard	10	100	mA	Frequency	50 kHz to 100 kHz	100	µA/A	2	95%	Yes			144
AC current: AC/DC transfer difference	AC/DC transfer standard	Comparison with reference standard	0.1	20	A	Frequency	40 Hz to 1000 Hz	200	µA/A	2	95%	Yes			145
AC current: AC/DC transfer difference	AC/DC transfer standard	Comparison with reference standard	0.1	20	A	Frequency	5 kHz	500	µA/A	2	95%	Yes			146
AC current up to 100 A: sources	Multifunction calibrator	AC/DC transfer standard with shunt, DC source	0.1	10	mA	Frequency	40 Hz to 1000 Hz	100	µA/A	2	95%	Yes			147
AC current up to 100 A: sources	Multifunction calibrator	AC/DC transfer standard with shunt, DC source	0.1	10	mA	Frequency	5 kHz	200	µA/A	2	95%	Yes			148
AC current up to 100 A: sources	Multifunction calibrator	AC/DC transfer standard with shunt, DC source	10	200	mA	Frequency	40 Hz to 1000 Hz	50	µA/A	2	95%	Yes			149
AC current up to 100 A: sources	Multifunction calibrator	AC/DC transfer standard with shunt, DC source	10	200	mA	Frequency	5 kHz	150	µA/A	2	95%	Yes			150
AC current up to 100 A: sources	Multifunction calibrator	AC/DC transfer standard with shunt, DC source	0.2	2	A	Frequency	40 Hz to 1000 Hz	100	µA/A	2	95%	Yes			151
AC current up to 100 A: sources	Multifunction calibrator	AC/DC transfer standard with shunt, DC source	0.2	2	A	Frequency	5 kHz	300	µA/A	2	95%	Yes			152

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AC current up to 100 A: sources	Multifunction calibrator	AC/DC transfer standard with shunt, DC source	2	10	A	Frequency	40 Hz to 1000 Hz	200	µA/A	2	95%	Yes			153
AC current up to 100 A: sources	Multifunction calibrator	AC/DC transfer standard with shunt, DC source	2	10	A	Frequency	5 kHz	500	µA/A	2	95%	Yes			154
AC current up to 100 A: meters	Digital multimeter	Direct with calibrator	0.1	10	mA	Frequency	40 Hz to 1000 Hz	100	µA/A	2	95%	Yes			155
AC current up to 100 A: meters	Digital multimeter	Direct with calibrator	0.1	10	mA	Frequency	5 kHz	200	µA/A	2	95%	Yes			156
AC current up to 100 A: meters	Digital multimeter	Direct with calibrator	10	200	mA	Frequency	40 Hz to 1000 Hz	50	µA/A	2	95%	Yes			157
AC current up to 100 A: meters	Digital multimeter	Direct with calibrator	10	200	mA	Frequency	5 kHz	150	µA/A	2	95%	Yes			158
AC current up to 100 A: meters	Digital multimeter	Direct with calibrator	0.2	2	A	Frequency	40 Hz to 1000 Hz	100	µA/A	2	95%	Yes			159
AC current up to 100 A: meters	Digital multimeter	Direct with calibrator	0.2	2	A	Frequency	5 kHz	300	µA/A	2	95%	Yes			160
AC power and energy: single phase ($f \leq 400$ Hz), active power	Power converter	Comparison with reference standard	0	30000	W	Voltage	1 V to 600 V	80	µW/VA	2	95%	Yes			161
						Current	0.05 A to 50 A								
						Frequency	50 Hz, 60 Hz								
						Power factor	1 to 0, inductive or capacitive								
AC power and energy: single phase ($f \leq 400$ Hz), active power	Power converter	Comparison with reference standard	0	600	W	Voltage	60 V to 120 V	50	µW/VA	2	95%	Yes			162
						Current	1 A to 5 A								
						Frequency	50 Hz, 60 Hz								
						Power factor	1 to 0, inductive or capacitive								
High DC voltage: high voltage meters	DC kilovoltmeter, dedicated set up for high voltage	Comparison with reference measuring system	1	80	kV			22	µV/V	2	95%	Yes			163
High DC voltage: ratios	High voltage resistive divider, DC high voltage probe	Comparison with reference measuring system	1.E-05	0.1		Input voltage	1 kV to 80 kV	22E-06		2	95%	Yes			164
						Output voltage	0.8 V to 1000 V								
High voltage impedance: capacitance	Compressed gas capacitor, capacitor for high voltage	Comparison with standard compressed gas capacitor	50	10000	pF	Voltage	1 kV to 100 kV	50	µF/F	2	95%	Yes			165

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						Frequency	50 Hz								
High voltage impedance: capacitance dissipation factor	Compressed gas capacitor, capacitor for high voltage	Dissipation factor measuring circuit	0	1.4E-03		Voltage	1 kV to 50 kV	1.0E-05		2	95%	No			166
						Frequency	50 Hz								
High voltage impedance: capacitance dissipation factor	Compressed gas capacitor, capacitor for high voltage	Dissipation factor measuring circuit	0	1.4E-03		Voltage	50 kV to 100 kV	3.0E-05		2	95%	No			167
						Frequency	50 Hz								
AC high voltage: meters	AC high voltage meter, dedicated set-up for high voltage measurements	Comparison with reference measuring system	1	100	kV	Frequency	50 Hz	2	mV/V	2	95%	Yes			168
AC high voltage: peak values	AC high voltage meter, dedicated set-up for high voltage measurements	Comparison with reference measuring system	1	800	kV	Frequency	50 Hz	10	mV/V	2	95%	Yes			168b
AC high voltage: ratio error	High voltage transformer: ratio error	Dedicated set-up for reference transformer calibration	0	0.1		Input voltage	200 V to 100 kV	50E-6		2	95%	No		This CMC is related to the next one	173
						Output voltage	100/1.73 V, 125 V								
						Frequency	50 Hz								
AC high voltage: ratio: phase displacement	High voltage trasformer: phase displacement	Dedicated set-up for reference transformer calibration	0	9999	μrad	Input voltage	200 V to 100 kV	50	μrad	2	95%	No		This CMC is related to the previous one	174
						Output voltage	100/1.73 V, 125 V								
						Frequency	50 Hz								
Pulsed high voltage and current: lightning impulse voltage parameters	Digital recorder, peak voltmeter: peak value	Dedicated measurement set-up	4	2000	V	Standard waveform	1.2/50 μs	7	mV/V	2	95%	Yes			175a
Pulsed high voltage and current: lightning impulse voltage parameters	Impulse calibrators: peak value	Comparison with reference measuring system	4	2000	V	Standard waveform	1.2/50 μs	7	mV/V	2	95%	Yes			175

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Calibration or Measurement Services			Measurand Level or Range			Measurement Conditions/Independent variables		Expanded Uncertainty							
Quantity	Instrument or artifact	Instrument Type or Method	Minimum value	Maximum value	units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Is the expanded uncertainty a relative one?	Uncertainty matrix	Comments	NMI Service Identifier
Pulsed high voltage and current: lightning impulse voltage parameters	Lightning impulse voltage measurement set-up: peak value	Comparison with reference measuring system	0.4	30	kV	Standard waveform	1.2/50 µs	10	mV/V	2	95%	Yes			176
Pulsed high voltage and current: lightning impulse voltage parameters	Lightning impulse voltage measurement set-up: peak value	Comparison with reference measuring system	20	200	kV	Standard waveform	1.2/50 µs	10	mV/V	2	95%	Yes			177
Pulsed high voltage and current: lightning impulse voltage parameters	Lightning impulse voltage measurement set-up: peak value	Comparison with reference measuring system and linearity test (IEC 60-2)	200	700	kV	Standard waveform	1.2/50 µs	20	mV/V	2	95%	Yes			178
Pulsed high voltage and current: lightning impulse time parameters	Digital recorder: front time	Dedicated measurement set-up	0.84	1.56	µs	Peak voltage	4 V to 2000 V	30	ms/s	2	95%	Yes			179a
Pulsed high voltage and current: lightning impulse time parameters	Digital recorder: time to half value	Dedicated measurement set-up	40	60	µs	Peak voltage	4 V to 2000 V	30	ms/s	2	95%	Yes			180a
Pulsed high voltage and current: lightning impulse time parameters	Impulse calibrators: front time	Comparison with reference measuring system	0.84	1.56	µs	Peak voltage	4 V to 2000 V	30	ms/s	2	95%	Yes			179
Pulsed high voltage and current: lightning impulse time parameters	Impulse calibrators: time to half value	Comparison with reference measuring system	40	60	µs	Peak voltage	4 V to 2000 V	30	ms/s	2	95%	Yes			180
Pulsed high voltage and current: lightning impulse time parameters	Lightning impulse voltage measurement set-up: front time	Comparison with reference measuring system	0.84	1.56	µs	Peak voltage	0.4 kV to 30 kV	30	ms/s	2	95%	Yes			181
Pulsed high voltage and current: lightning impulse time parameters	Lightning impulse voltage measurement set-up: time to half value	Comparison with reference measuring system	40	60	µs	Peak voltage	0.4 kV to 30 kV	30	ms/s	2	95%	Yes			182

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Calibration or Measurement Services			Measurand Level or Range			Measurement Conditions/Independent variables		Expanded Uncertainty							
Quantity	Instrument or artifact	Instrument Type or Method	Minimum value	Maximum value	units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Is the expanded uncertainty a relative one?	Uncertainty matrix	Comments	NMI Service Identifier
Pulsed high voltage and current: lightning impulse time parameters	Lightning impulse voltage measurement set-up: front time	Comparison with reference measuring system	0.84	1.56	μs	Peak voltage	20 kV to 200 kV	30	ms/s	2	95%	Yes			183
Pulsed high voltage and current: lightning impulse time parameters	Lightning impulse voltage measurement set-up: time to half value	Comparison with reference measuring system	40	60	μs	Peak voltage	20 kV to 200 kV	30	ms/s	2	95%	Yes			184
Pulsed high voltage and current: lightning impulse time parameters	Lightning impulse voltage measurement set-up: front time	Comparison with reference measuring system	0.84	1.56	μs	Peak voltage	200 kV to 700 kV	50	ms/s	2	95%	Yes			185
Pulsed high voltage and current: lightning impulse time parameters	Lightning impulse voltage measurement set-up: front time	Comparison with reference measuring system	40	60	μs	Peak voltage	200 kV to 700 kV	50	ms/s	2	95%	Yes			186
Electric discharge: apparent charge	Partial discharge calibrator	Comparison with reference charge	0.5	5	pC			30	mC/C	2	95%	Yes			187
Electric discharge: apparent charge	Partial discharge calibrator	Comparison with reference charge	5	50000	pC			10	mC/C	2	95%	Yes			188
High AC current: ratio error	Current transformer	Dedicated set-up for current transformer calibration	0	9.99E-03		Input current	0.1 A to 6 A	20.E-06		2	95%	No		This CMC is related to the next one	189a
						Rated output current	5 A								
						Ratio	0.4 to 1								
						Frequency	40 Hz to 60 Hz								
High AC current: ratio: phase displacement	Current transformer	Dedicated set-up for current transformer calibration	0	9990	μrad	Input current	0.1 A to 6 A	30	μrad	2	95%	No		This CMC is related to the previous one	194a
						Rated output current	5 A								
						Ratio	0.4 to 1								
						Frequency	40 Hz to 60 Hz								
High AC current: ratio error	Current transformer	Dedicated set-up for current transformer calibration	0	9.99E-03		Input current	0.05 A to 0.1 A	20E-06		2	95%	No		This CMC is related to the next one	190a
						Rated output current	5 A, 1 A								
						Ratio	1 to 240								

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Calibration or Measurement Services			Measurand Level or Range			Measurement Conditions/Independent variables		Expanded Uncertainty							
Quantity	Instrument or artifact	Instrument Type or Method	Minimum value	Maximum value	units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Is the expanded uncertainty a relative one?	Uncertainty matrix	Comments	NMI Service Identifier
						Frequency	40 Hz to 60 Hz								
High AC current: ratio: phase displacement	Current transformer	Dedicated set-up for current transformer calibration	0	9990	µrad	Input current	0.05 A to 0.1 A	20	µrad	2	95%	No		This CMC is related to the previous one	194b
						Rated output current	5 A, 1 A								
						Ratio	1 to 240								
						Frequency	40 Hz to 60 Hz								
High AC current: ratio error	Current transformer	Dedicated set-up for current transformer calibration	0	9.99E-03		Input current	0.1 A to 1500 A	10E-06		2	95%	No		This CMC is related to the next one	189
						Rated output current	5 A, 1 A								
						Ratio	1 to 240								
						Frequency	40 Hz to 60 Hz								
High AC current: ratio: phase displacement	Current transformer	Dedicated set-up for current transformer calibration	0	9990	µrad	Input current	0.1 A to 1500 A	10	µrad	2	95%	No		This CMC is related to the previous one	195
						Rated output current	5 A, 1 A								
						Ratio	1 to 240								
						Frequency	40 Hz to 60 Hz								
High AC current: ratio error	Current transformer	Dedicated set-up for current transformer calibration	0	9.99E-03		Input current	2.4 A to 7200 A	50E-06		2	95%	No		This CMC is related to the next one	193
						Rated output current	5 A, 1A								
						Ratio	240 to 1200								
						Frequency	50 Hz								
High AC current: ratio: phase displacement	Current transformer	Dedicated set-up for current transformer calibration	0	9990	µrad	Input current	2.4 A to 7200 A	50	µrad	2	95%	No		This CMC is related to the previous one	199
						Rated output current	5 A, 1A								
						Ratio	240 to 1200								
						Frequency	50 Hz								
High AC current: pulsating current	Pulsating current measurement set up, peak value	Comparison with reference set up	0.1	170	kA	AC component	50 Hz	15	mA/A	2	95%	Yes			201
High AC current: pulsating current	Pulsating current measurement set up, let-through energy	Comparison with reference set up	1E-05	6400	k(A ² s)	Prospective current (rms)	0.1 kA to 80 kA	70E-03		2	95%	Yes			202
						Duration	0.001 s to 3 s								

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Calibration or Measurement Services			Measurand Level or Range			Measurement Conditions/Independent variables		Expanded Uncertainty							
Quantity	Instrument or artifact	Instrument Type or Method	Minimum value	Maximum value	units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Is the expanded uncertainty a relative one?	Uncertainty matrix	Comments	NMI Service Identifier
						AC component	50 Hz								
Electric fields below 50 kHz: electric field strength	AC electric field meter	Direct comparison with standard	1	40000	V/m	Frequency	50 Hz	2.6E-03		2	95%	Yes			203
Electric fields below 50 kHz: electric field strength	AC electric field meter	Direct comparison with standard	1	500	V/m	Frequency	10 Hz to 2000 Hz	2.6E-03		2	95%	Yes			204
Magnetic fields below 50 kHz: magnetic flux	Flux meter	Reference mutual inductor and ballistic setup	1E-04	2E-02	Wb	Inductor current	< 2 A	1 to 2	mWb/Wb	2	95%	yes			205a
Magnetic fields below 50 kHz: DC magnetic flux density	Magnetic field density meter	Nuclear Magnetic Resonance	3.60E-02	1.50E+00	T	Field gradient	< 0.2 (mT/T)/cm	20	µT/T	2	95%	Yes			205
Magnetic fields below 50 kHz: DC magnetic flux density	Magnetic field density meter	Nuclear Magnetic Resonance and Helmholtz coils	1.00E-03	4.00E-02	T	Field gradient	< 0.2 (mT/T)/cm	0.15	mT/T	2	95%	Yes			206
						Coil current	< 2 A								
Magnetic fields below 50 kHz: DC magnetic flux density	Magnetic field density meter	Helmholtz coils	1.00E-05	1.50E-03	T	Coil current	< 2 A	0.5 to 2	mT/T	2	95%	Yes			207
Magnetic fields below 50 kHz: AC magnetic flux density	Magnetic flux density meter	Direct comparison with standard	0.1	3000	µT	Frequency	20 Hz to 1 kHz	7 to 28	mT/T	2	95%	Yes	AC_B_1		208
Magnetic fields below 50 kHz: turn area	Pickup coil	Helmholtz coils, ballistic setup, fluxmeter	5.00E-03	5.00E-01	m ²	Coil length	< 40 mm	2E-03		2	95%	Yes			210
Electromagnetic fields above 50 kHz: electric field strength	Field probe	Reference field in TEM cell	1	60	V/m	Frequency	0.1 MHz to 200 MHz	100E-03		2	95%	Yes			211
Electromagnetic fields above 50 kHz: electric field strength	Field probe	Reference field in G-TEM cell	1	50	V/m	Frequency	200 MHz to 1000 MHz	200E-03		2	95%	Yes			212
Electromagnetic fields above 50 kHz: magnetic field strength	Field probe	Reference field in TEM cell	3	200	mA/m	Frequency	0.1 MHz to 200 MHz	100E-03		2	95%	Yes			213
Electromagnetic fields above 50 kHz: magnetic field strength	Field probe	Reference field in G-TEM cell	3	150	mA/m	Frequency	200 MHz to 1000 MHz	200E-03		2	95%	Yes			214

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Calibration or Measurement Services			Measurand Level or Range			Measurement Conditions/Independent variables		Expanded Uncertainty							
Quantity	Instrument or artifact	Instrument Type or Method	Minimum value	Maximum value	units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Is the expanded uncertainty a relative one?	Uncertainty matrix	Comments	NMI Service Identifier
Soft magnetic sheet materials: specific total power loss	Epstein, ring and single sheet sample	Hysteresisgraph-wattmeter (IEC 60404-2, IEC 60404-3)	0.01	500	W/kg	Frequency	2 Hz to 400 Hz	10E-03 to 20E-03		2	95%	Yes			240
						Polarisation	0.2 T to 1.8 T								
						Sample mass	> 0.1 kg								
						Primary current	< 15 A								
Soft magnetic sheet materials: peak value of DC magnetic polarisation	Epstein, ring and single sheet sample	Ballistic setup, fluxmeter	0.05	2	T	Magnetic flux	> 0.1 mWb	2E-03 to 10E-03		2	95%	Yes			241
						Primary current	< 15 A								
Soft magnetic sheet materials: peak value of AC magnetic polarisation	Epstein, ring and single sheet sample	Mean value voltmeter	0.01	1.8	T	Frequency	2 Hz to 400 Hz	1E-03 to 5E-03		2	95%	Yes			242
						Primary current	< 15 A								
Soft magnetic sheet materials: peak value of magnetic field strength	Epstein, ring and single sheet sample	Peak value voltmeter	0.5	10000	A/m	Primary current	< 15 A	2E-03 to 10E-03		2	95%	Yes			243
Soft magnetic sheet materials: RMS value of magnetic field strength	Epstein, ring, and single sheet sample	RMS value voltmeter	5.00E-01	1.00E+04	A/m	Primary current	< 15 A	2E-03 to 10E-03		2	95%	Yes			243a
						Form factor	1.1107 ±1%								
Soft magnetic sheet materials: specific apparent power	Epstein, ring and single sheet sample	Hysteresisgraph-wattmeter (IEC 60404-2, IEC 60404-3)	5.00E-03	200	VA/kg	Frequency	2 Hz to 400 Hz	10E-03 to 40E-03		2	95%	Yes			244
						Polarisation	0.2 T to 1.8 T								
						Sample mass	> 0.1 kg								
						Primary current	< 15 A								
Soft magnetic sheet materials: peak permeability	Epstein, ring, and single sheet sample	Hysteresisgraph-wattmeter (IEC 60404-2, IEC 60404-3)	1.00E-04	1.00E-01	H/m	Frequency	2 Hz to 400 Hz	5E-03 to 20E-03		2	95%	Yes			244a
						Polarisation	0.2 T to 1.8 T								
						Sample mass	> 0.1 kg								
						Primary current	< 15 A								

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Calibration or Measurement Services			Measurand Level or Range			Measurement Conditions/Independent variables		Expanded Uncertainty							
Quantity	Instrument or artifact	Instrument Type or Method	Minimum value	Maximum value	units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Is the expanded uncertainty a relative one?	Uncertainty matrix	Comments	NMI Service Identifier
Soft magnetic sheet materials: density	Epstein strip (Fe-Si)	Four-point resistivity measurement (IEC 60404-13)	7620	7890	kg/m ³	Current	> 1 A	5E-03		2	95%	Yes			244b
Soft magnetic sheet materials: resistivity	Epstein strip (Fe-Si)	Four-point resistivity measurement (IEC 60404-13)	1.2E-07	5.3E-07	Ωm	Current	> 1 A	2E-03		2	95%	Yes			244c
Soft magnetic bulk materials: magnetic polarisation	Rod, cylinder	Permeameter, ballistic setup (IEC 60404-4)	0.05	2.3	T	Rod length	> 100 mm	10E-03		2	95%	Yes			245
						Cross-sectional area	> 10 mm ²								
						Applied field	< 2E+05 A/m								
Soft magnetic bulk materials: magnetic field strength	Rod, cylinder	Permeameter, ballistic setup, Hall probe gaussmeter (IEC 60404-4)	100	100000	A/m	Rod length	> 100 mm	20E-03		2	95%	Yes			246
						Cross-sectional area	> 10 mm ²								
Soft magnetic bulk materials: remanent magnetic flux density	Rod, cylinder	Permeameter, ballistic setup (IEC 60404-4)	0.02	2	T	Rod length	> 100 mm	20E-03		2	95%	Yes			247
						Cross-sectional area	> 10 mm ²								
Feebly magnetic, paramagnetic and diamagnetic materials: DC magnetic susceptibility	Rod, cylinder	Solenoid, compensated winding, ballistic setup	0.01	2		Rod diameter	> 5 mm	2E-03 to 10E-03		2	95%	Yes			248
						Rod length / rod diameter	> 4								
Hard magnetic materials: remanent magnetic flux density	Cylinder, rectangular parallelepiped	Electromagnet, hysteresisgraph (IEC 60404-5)	0.02	1.5	T	Sample length	> 8 mm	10E-03 to 40E-03		2	95%	Yes			249
Hard magnetic materials: coercive field strength (H_{CB} , H_{CI})	Cylinder, rectangular parallelepiped	Electromagnet, Hall probe gaussmeter, hysteresisgraph (IEC 60404-5)	1	1000	kA/m	Sample length	> 8 mm	10E-03 to 40E-03		2	95%	Yes			250

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Calibration or Measurement Services			Measurand Level or Range			Measurement Conditions/Independent variables		Expanded Uncertainty							
Quantity	Instrument or artifact	Instrument Type or Method	Minimum value	Maximum value	units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Is the expanded uncertainty a relative one?	Uncertainty matrix	Comments	NMI Service Identifier
Hard magnetic materials: magnetic moment	Sphere	Vibrating sample magnetometer	1.00E-05	0.1	Am ²	Sample diameter	< 3 mm	10E-03 to 50E-03		2	95%	Yes			251
Hard magnetic materials: magnetic polarisation	Cylinder, rectangular parallelepiped	Electromagnet, hysteresisgraph (IEC 60404-5)	0.02	1.5	T	Sample length	> 8 mm	10E-03 to 30E-03		2	95%	Yes			252

Electricity and Magnetism, Italy, IEN (Istituto Elettrotecnico Nazionale Galileo Ferraris)
uncertainties table: ACV_M1

AC voltage up to 1000 V: meters, IEN Internal Identifier: 105a

	< 40 Hz	40 Hz to 10 kHz	10 kHz to 30 kHz	30 kHz to 50 kHz	50 kHz to 100 kHz	100 kHz to 300 kHz	300 kHz to 1 MHz
200 mV to 0.5 V	40	20	20	20	25	100	500
0.5 V to 20 V	30	15	15	15	25	70	450
20 V to 100 V	40	20	20	50	55	-	-
100 V to 400 V	50	25	60	60	90	-	-
400 V to 700 V	50	30	90	110	150	-	-
700 V to 1000 V	80	45	90	-	-	-	-

The expanded uncertainties given in this table are expressed in $\mu\text{V/V}$

Electricity and Magnetism, Italy, IEN (Istituto Elettrotecnico Nazionale Galileo Ferraris)
uncertainties table: ACDC_MV

AC voltage: AC/DC transfer difference at low voltages, IEN Internal Identifier: 59a

	40 Hz to 20 kHz	20 kHz to 50 kHz	50 kHz to 100 kHz	100 kHz to 500 kHz	500 kHz to 1 MHz
1 mV to 3 mV	300	300	400	500	1000
3 mV to 10 mV	100	100	150	200	400
10 mV to 30 mV	60	60	80	150	300
30 mV to 100 mV	30	30	40	60	150
100 mV to 300 mV	25	25	30	60	120

The expanded uncertainties given in this table are expressed in $\mu\text{V/V}$

Electricity and Magnetism, Italy, IEN (Istituto Elettrotecnico Nazionale Galileo Ferraris)
uncertainties table: ACDC_M1

AC voltage: AC/DC transfer difference at medium voltages, IEN Internal Identifier: 66.a

AC voltage: AC/DC transfer difference at high voltages, IEN Internal Identifier: 73.a

	40 Hz to 20 kHz	20 kHz to 50 kHz	50 kHz to 100 kHz	100 kHz to 500 kHz	500 kHz to 1 MHz
0.2 V to 0.5 V	7	8	10	16	30
0.5 V to 10 V	4	5	6	16	30
10 V to 20 V	5	6	7	20	50
20 V to 100 V	15	20	30	-	-
100 V to 500 V	20	25	50	-	-
500 V to 1000 V	30	40	100	-	-

The expanded uncertainties given in this table are expressed in $\mu\text{V/V}$

Electricity and Magnetism, Italy, IEN (Istituto Elettrotecnico Nazionale Galileo Ferraris)
uncertainties table: AC_B_1

Magnetic fields below 50 kHz: AC magnetic flux density, IEN Internal Identifier: 208

	20 Hz to 300 Hz	400 Hz	500 Hz	600 Hz	700 Hz	800 Hz	900 Hz	1000 Hz
0.1 µT	21	21	22	22	23	24	26	28
0.2 µT	12	13	13	14	15	17	20	23
0.3 µT	10	10	11	12	13	15	18	21
0.4 µT	9	9	10	11	13	15	18	21
0.5 µT	8	9	9	11	12	15	17	21
0.6 µT	8	8	9	10	12	14	17	21
0.7 µT	8	8	9	10	12	14	17	20
0.8 µT	7	8	9	10	12	14	17	20
0.8 µT to 1000 µT	7	8	9	10	12	14	17	20
1000 µT to 3000 µT	7	-	-	-	-	-	-	-

The expanded uncertainties given in this table are expressed in mT/T